Int. J. Nonlinear Anal. Appl.
Volume 11, Special Issue, Winter and Spring 2020, No. 5, 63-79
ISSN: 2008-6822 (electronic)
http://dx.doi.org/10.22075/ijnaa.2020.4525

Measuring and Explaining the Probability of Informed Trading and its Relationship with the Cost of Capital with an Emphasis on Family Ownership

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Abstract

One of the most important topics studied in the field of market microstructures is to measure information asymmetry in the capital market. In recent years, the Probability of Informed Trading (PIN) has been introduced to measure information asymmetry. The use of private information in stock exchanges reduces stock liquidity, thereby increasing the cost of equity capital. The main purpose of this study is to investigate the relationship between the probability of informed trading and cost of capital as well as to examine the moderating role of family ownership in the relationship between the probability of informed trading and cost of capital in 113 companies listed on the Tehran Stock Exchange during 2012-2016.

The independent variable of information asymmetry is measured by the probability of informed trading criterion and the dependent variable of cost of capital by the criterion of cost of equity and cost of debt, and the weighted average cost of capital, and the moderating variable is family ownership. The research method is correlational and the multivariate regression using combined data with fixed effect regression model approach is used.

The research findings show that there is a positive and significant direct relationship between the probability of informed trading with the cost of equity and the weighted average cost of capital, as well as the variable of family ownership has a positive and significant direct effect on the relationship between the probability of informed trading and the weighted average cost of capital.

When the probability of trading by private information holders increases, due to the increase in information asymmetry between informed and uninformed investors, uninformed investors demand higher returns to cover the investment risk, thereby increasing the company's cost of capital. This will increase the cost of financing through bonds.

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Received: January 2020 *Revised:* May 2020

Keywords: probability of informed trading, cost of capital, family ownership.

1. Introduction

This study investigates the relationship between the probability of informed trading and the cost of capital with emphasis on family ownership in companies listed on the Tehran Stock Exchange. One of the important points about the Stock Exchange is the issue of market efficiency, according to which all the information available in the market reflects its effect on stock prices. Perhaps from the point of view of market efficiency hypothesis, the reason for the existence of accounting is the information asymmetry in which one of the parties to the exchange has more information than the other party. This is due to intra-group trading and information [26]. Among the factors affecting the cost of capital are information and the risk associated with it. Information risk means that some traders have information (such as company's private information) that others do not. If some investors who have private information about the company use the information mentioned in the stock exchanges, the information asymmetry will intensify and investors will not be willing to buy the company's share, and if they purchase stocks, in exchange for bearing the risk of trading, will expect to receive more returns. This indicates an increase in the cost of capital [22]. O'Hara [20] and Easley and O'Hara [10] believe that information asymmetry affects prices and is an indicator of corporate cost of capital. They state that the information asymmetry between market traders leads to the selection and maintenance of different and various portfolios by them. Therefore, traders with little information will try to keep assets that can compensate for the weakness caused by unequal information. This will reduce the price of securities with high levels of information asymmetry, reduce their liquidity, and increase their trading costs during trade. Investors demand more rewards to increase the cost of trading, and as a result, the cost of capital associated with these companies increases. By reducing information asymmetry through disclosing private information and improving the quality of disclosure, companies will be able to reduce information asymmetry and the cost of exchanging securities and thus the cost of capital. Easley et al. [11] proposed a method to calculate the probability of using private information in stock exchanges using market microstructures. A company's cost of capital is the minimum rate of return that its acquisition requires to maintain the market value of the company (or its stock price). Managers need to have the sufficient information about the cost of capital, often called the expected rate of return, for making decisions about capital budgeting, establishing the optimal structure of capital, making decisions about long-term or short-term leases, and managing the working capital [26]. The basis of research on family ownership is the issue of agency. Due to the structure and characteristics of family ownership, family owners are expected to be more sensitive to the added value of the company, leading to more incentives than non-family corporates to control costs (including costs of agency and related costs such as cost of capital) through better disclosure and elimination of information asymmetry [4]. On the other hand, the presence of family owners in the executive activities and the possibility of obtaining information through various channels lead to more accurate monitoring of executive management and reduction of agency issues between managers-owners. Therefore, it is possible that family corporates incur more potential costs compared to the benefits of timely and high-quality disclosure of information and therefore prefer less disclosure [24], leading to increased information asymmetry and cost of capital cost.

Some researchers such as Easley & O'Hara [10] Zhang & Ding [29] Saini & Hermann [23] Fu et al. [13] He et al. [15] in their research showed that there is a direct relationship between information asymmetry and cost of capital. In other words, there is an inverse relationship between disclosure and cost of capital. They indicated that the information asymmetry between traders causes the

uninformed trader to bear more information risk and to demand a higher return to bear the mentioned risk. This increases the common stock capital cost.

On the other hand, the results of the research of some other researchers such as Khani & Qajavand [17] revealed that as long as capital markets are in full competition, information asymmetry will not affect the cost of capital. The study results of Botosan's [2] indicated that for companies in which the pursuit of analysts is low, increasing disclosure reduces the cost of capital, but for companies with high pursuit of analysts, there is no evidence of relationship between the amount of disclosure and the cost of capital.

The main purpose of this study is to investigate the relationship between the probability of informed trading and the cost of capital with emphasis on family ownership. The independent variable of information asymmetry is measured by PIN criterion, and the dependent variable of capital cost by the criterion of cost of equity, cost of debt, and the weighted average cost of capital. Family ownership is also considered as a moderator variable. The authors' motivation for writing this paper is that most research has been done on the relationship between the probability of informed trading and cost of capital in developed countries (not in developing countries). The results of previous research are also inconsistent, as each has used different criteria to study information asymmetry and cost of capital. There are also different rules for reporting information and dealing with trading based on the private information in different countries. In Iran, too, due to the different approach to information asymmetry, there is private information in stock exchange. Therefore, it seems necessary to investigate the probability of informed trading that can lead to a better understanding of the concept of information asymmetry. Therefore, the main question of this study is what is the relationship between the probability of informed trading and the cost of capital, taking into account the ownership of companies listed on the Tehran Stock Exchange. The results of this study can expand the theoretical foundations of texts related to information asymmetry and cost of capital, as well as determine the type of relationship between the probability of informed trading and cost of capital in companies listed on the Tehran Stock Exchange and its scientific achievement can provide useful information to corporate executives and the Stock Exchange Organization. The results of the research could also suggest new ideas for conducting new research on information asymmetry and cost of capital. In the following, by providing the theoretical and empirical background, research hypotheses will be developed and a complete explanation of how to measure variables will be given. The research model is then explained and the results and findings of the implementation of the model are presented. At the end, the suggestions and limitations of the research will be presented.

2. Research background

2.1. Theoretical background

Theoretical background of research is the theories and scientific models that the researcher chooses as the cornerstone of his/her research to explain the results of his/her research for testing the theory or model.

2.2. Information asymmetry

There are two main types of information asymmetry. The first type of information asymmetry is called adverse selection, which is the source of many problems. There is information asymmetry because one party of the trade has information that the other does not have. The second type of information asymmetry is called moral hazard. Many problems can be found on moral hazard. Companies' managers may make decisions that are profitable for shareholders but harmful for bondholders. In all these cases, information asymmetry occurs. Because some trading parties cannot

observe the actions and decisions of other trading parties that affect the interests of all trading parties. Thus, information asymmetry is created when one or more investors have private information about the company's value, while others only have access to public information. Repetition of information asymmetry raises the issue of different choices among investors due to private information [16]. Criteria for information asymmetry in the market fall into three general categories [5]. The measure of a company's growth opportunity is one of the indicators for measuring information asymmetry, so that companies with higher growth opportunities have a more asymmetric information environment. Non-convergence in analysts' opinions is another indicator for measuring information asymmetry, so that a higher level of information symmetry among analysts leads to convergence in expectations regarding the company's expected future earnings. These studies typically use the criteria resulting from the agreement between analysts' earnings per share forecasts as an indicator of the level of information asymmetry. The third group of studies use a series of criteria based on market microstructures (such as the probability of informed trading), which is more common than the previous two groups. New criteria such as probability of information-based stock exchange (PIN) are one of the most important indicators for measuring the information asymmetry recently introduced in the financial literature and market microstructure literature, and many studies have been conducted in recent years to measure the amount of information asymmetry obtained from stock markets of different countries. In terms of the criteria for measuring the information asymmetry based on the market microstructure literature, the stock trading price range was first proposed by Demsetz [6]. The proposed stock trading price range has been widely used in previous research as a measure of information asymmetry; But the index of the difference between the proposed trading price is very simple and cannot show the information asymmetry well in the market. Thus, based on the microstructure of the capital market and the proposed trading price, Easley and O'Hara [8, 9] provided a model of the flow of unusual orders in the market, based on which probability of a random trading by an informed trader can be estimated, such that the larger PIN values in the range of 0 to 1 indicate the existence of more private information or higher level of information asymmetry [28]. The basic premise of this model is that public information is reflected directly and without the need for trading activity in the price, while private information is reflected during unusual orders (excess sell or buy orders). In general, information available in the financial markets is classified into two categories: public information and private information. Public information is information that has been made public, and private information is that part of the information that has not been made public. Informed traders have private information about stocks, while uninformed investors do not have such information. Easley and O'Hara [9] have defined the probability of information-based stock trading for specific stock $i(PIN_i)$ as the estimated entry rate of the information-based trading divided by the estimated entry rate of all trades in a given day [27].

2.3. Cost of capital

Cost of capital is the minimum rate of return that is necessary to maintain the market value of a company (or its stock price). Cost of capital is calculated on the basis of the weighted average of the various components of the company's capital such as debt, preferred stocks, common stocks and retained earnings. The use of book value to calculate cost of capital will result in underestimating the actual cost of capital for companies and overestimating the actual economic value added [14].

2.4. Information asymmetry and cost of capital

O'Hara [20] and Easley and O'Hara [10] believe that information asymmetry affects prices and is an indicator of corporate cost of capital. They state that the information asymmetry between market traders leads to the selection and maintenance of different and various portfolios by them. Therefore,

traders with little information will try to keep assets that can compensate for the weakness caused by unequal information. This will reduce the price of securities with high levels of information asymmetry, reduce their liquidity, and increase their trading cost during transaction. Investors demand more rewards to increase the cost of trading, and as a result, the cost of capital associated with these companies increases. By reducing information asymmetry through disclosing private information and improving the quality of disclosure, companies will be able to reduce information asymmetry and the cost of exchanging securities and thus the cost of capital. As a result, companies with less information asymmetry and a clearer, higher-quality information environment are expected to have more stock liquidity and therefore lower cost of capital. The basis of research on family ownership is the issue of agency. Due to the structure and characteristics of family corporates, family owners are expected to be more sensitive to the added value of the company, leading to more incentives than non-family corporates to control costs (including costs of agency and related costs such as cost of capital) through better disclosure and elimination of information asymmetry [4]. On the other hand, the presence of family owners in executive activities and the possibility of obtaining information through various channels lead to more accurate monitoring of executive management and reduction of agency issues between managers-owners. Therefore, it is possible that family corporates incur more potential costs compared to the benefits of timely and high-quality disclosure of information and therefore prefer less disclosure [25] leading to increased information asymmetry and cost of capital.

2.5. Empirical background

In a study entitled Disclosure, Liquidity, and Cost of Capital, Diamond and Verrecchia [7] showed that disclosure of public information to reduce information asymmetry can reduce the company's cost of capital by increasing the growing demand of large investors to increase stock liquidity. Ebihara et al. [12] in a study entitled Market Liquidity, Private Information, and the Cost of Capital examined cost of capital, information asymmetry, and market liquidity in Japanese family and non-family corporates. The results of their study showed that the cost of debt capital and the cost of equity in family corporates are higher than those in non-family corporates, but this difference is not significant. Also, the weighted average cost of capital in family corporates is higher than that in non-family corporates, and this difference is significant because family corporates in Japan use less leverage. Finally, the shares of family corporates are traded with a higher level of information asymmetry than non-family corporates. In their study Price, Trade Size, and Information in Securities Markets based on the market microstructure and the proposed trading price, Easley and O'Hara [8] provided a model of the flow of unusual orders in the market, based on which probability of a random trading (PIN) by an informed trader can be estimated. Easley and O'Hara [9] showed in the study Time and the Process of Security Price Adjustment that when information asymmetry increases, we will also see an increase in the trade size. In a study entitled The Level of Disclosure and Cost of Equity Capital, Botosan [2] examined the relationship between the level of disclosure and the cost of capital of American companies. The results indicated that for companies in which the pursuit of analysts is low, increasing disclosure reduces the cost of capital, but for companies with high pursuit of analysts, there is no evidence indicating a relationship between the amount of disclosure and the cost of capital. In a study entitled Corporate Disclosure Quality and the Cost of Debt. Easley et al. [11] used a cross-sectional Fama-MacBeth regression to show that there was a positive significant relationship between PIN and companies' monthly returns. In their study Information and the Cost of Capital, Easley and O'Hara [10] showed that information asymmetry between informed and uninformed traders affects the cost of common stock capital. They also showed that the information asymmetry between traders causes the uninformed trader to bear more information risk and to demand a higher return for bearing the

mentioned risk. This increases the cost of common stock capital. Saini & Herrmann [23] conducted a study entitled Cost of Equity Capital, Information Asymmetry, and Segment Disclosure. The results of their research indicated a negative and significant relationship between the cost of equity capital and the level of disclosure of segment information. There was also a positive and significant relationship between the cost of equity capital and the effects caused by information asymmetry. In other words, the high information asymmetry leads to a strong and significant negative relationship between the cost of equity capital and the level of disclosure of segment information. Fu et al. [13] investigated the impact of financial reporting frequency on information asymmetry and the cost of capital and found that increasing financial reporting frequency is associated with a decrease in corporate information asymmetry and cost of capital. Moreover, mandatory changes in the number of financial statements also showed similar results. Akins et al. [1] studied investor competition over information and the pricing of information asymmetry. The results of the study showed that in the conditions of incomplete competition, information asymmetry between traders causes the stock price to decrease compared to the full competition. Information asymmetry leads to liquidity supply, affecting the company's cost of capital. Hence, there is a positive relationship between informed (or uninformed) traders and the cost of capital. He et al. [15] conducted a study entitled The Relationship between Information Asymmetry and Cost of Equity Capital. The results of their research indicated that there was a significant positive relationship between information asymmetry and returns expected by investors. Also, the instability in revenue forecasting led to an increase in the cost of equity capital. In other words, information asymmetry and uncertainty in information have led to an increase in the cost of capital. Chang et al [3] examined how private information affects stock pricing. In this study, they provided a dynamic measure of the probability of informed trading (DPIN) in a situation where data frequencies were high. Chang et al [3] calculated this dynamic measure for data from the Center for Research in Security Prices (CRSP) and then tested the relationship between private information and firm-specific return variation. Petacchi [21] In his study, Information Asymmetry and Capital Structure, used honest disclosure of rules as an external impulse to the information environment to determine the causal relationship between information asymmetry and the company's financial behavior. The researcher found that companies with a high level of information asymmetry increased their debt compared to the companies with a low level of information asymmetry after the honest disclosure of the rules.

Moghadam et al [18] conducted a study entitled The Effect of Information Asymmetry on the Relationship between Earnings Quality and Cost of Common Stock Capital during the period 2007-2012 using data from 76 companies from the Tehran Stock Exchange in Iran with the combined data analysis method. To test the research hypothesis, they used the multivariate linear regression model and to estimate its parameters, they used the ordinary least squares method. The results showed that the earning quality has a direct and significant effect on the cost of common stock capital. There is also a significant inverse relationship between the earning quality and the cost of common stock capital, which has been adjusted by information asymmetry. Khani and Qajavand [17] performed a study entitled The Effect of Competitive Market Spectrum on the Relationship between Information Asymmetry and Cost of Common Stock Capital during the period 2004- 2009 using data from 70 companies from Tehran Stock Exchange in Iran by time series data analysis method. The multivariate linear regression model was used to test the research hypothesis, and the ordinary least squares method to estimate its parameters. The results showed that at the level of full competition, the criteria for measuring information asymmetry have no significant relationship with the cost of capital, and also the market of incomplete competition is a factor affecting the relationship between information asymmetry and cost of common stock capital. Setayesh et al [26] investigated the effect of information asymmetry on the cost of capital during the period 2004-2011 using data from 94

companies from Tehran Stock Exchange in Iran by the combined data analysis method. To test the research hypothesis, they used a multivariate regression model and to estimate its parameters, they used the ordinary least squares method. The results showed that there is a significant relationship between information asymmetry and two criteria of cost of capital, namely cost of common stock capital and debt cost, but there is no significant relationship between information asymmetry and two other criteria of cost of capital, i.e. the cost of retained earning capital and the weighted average cost of capital.

2.6. Research hypotheses

In order to achieve the goals of the research and answer the research questions, the following hypotheses are developed and tested:

H1. There is a significant relationship between the PIN and the cost of equity capital.

H2. There is a significant relationship between the PIN and the cost of debt.

H3. There is a significant relationship between the PIN and the weighted average cost of capital.

H4. Family ownership moderates the relationship between the PIN and the weighted average cost of capital.

3. Research Methodology

3.1. Statistical community and sample

In the present study, a systematic removal method has been used to determine the statistical sample. For this purpose, those companies of the statistical community with the required conditions are selected as the statistical samples and the rest are removed. The financial year of the company is the end of March of each year and the company has not changed the financial year during the desired period. The studied companies are not part of the investment companies, holding companies, financial intermediaries and insurance companies. Their information and data are available. The company's stock exchanges have been done continuously on the Tehran Stock Exchange and have not stopped trading for more than three months. According to the above conditions and restrictions, out of the companies listed on the Tehran Stock Exchange, a total of 113 companies have been selected as the statistical sample of the research.

3.2. Measurement of the research variables

Dependent variable – Cost of Capital (COC): The company's cost of capital is calculated based on the market value of the debt and the company's equity.
A. Cost of Equity (COE): According to Gordon's model (1982), the cost of common stock capital can be obtained using the following method:

$$COE_{it} = \frac{D_{it+1}}{P_{it}} + G_i \tag{3.1}$$

The growth rate is calculated using the geometric mean of sales growth:

$$G_i = \left(S_{95}|S_{91}\right)^{1/4} - 1 \tag{3.2}$$

B. Cost of Debt (COD): The after-tax cost of debt rate is used as the cost of debt, and this rate is the cost of debt rate after deducting the tax savings calculated according to the following equation:

$$COD_{it} = K_b(1-t) \tag{3.3}$$

C. The Weighted Average Cost of Capital (WACC): The following equation is used to calculate the weighted average cost of capital:

$$WACC_{it} = \left(W_{coe} \times COE_{it}\right) + \left(W_{cod} \times COD_{it}\right) \tag{3.4}$$

Independent variable - Probability of Informed Trading (PIN): In the field of information asymmetry measurement criteria based on the market microstructure literature, Easley and O'Hara (2002) provided a model of the flow of unusual orders in the market, based on which probability of a random trading by an informed trader can be estimated, such that the larger PIN values in the range of 0 to 1 indicate the existence of more private information or higher level of information asymmetry [28]. The basic premise of this model is that public information is reflected directly and without the need for trading activity in the price, while private information is reflected during unusual orders (excess sell or buy orders). Easley and O'Hara [9] have defined the probability of information-based stock trading as the estimated entry rate of the information-based trading divided by the estimated entry rate of all trades in a given day [27].

$$PIN_{it} = \frac{\alpha\mu}{\alpha\mu + 2\varepsilon} \tag{3.5}$$

Where α is the probability of an information event, δ is the probability of a bad information event (bad news), and $\delta - 1$ is the probability of a good information event (good news) on a given day. If no information event occurs on a given day, only uninformed traders (liquidity) in the market are to trade with the probability of $(1-\alpha)$, And on such a day, the entry rate of uninformed traders, both for buying and selling, has an independent Poisson distribution with a probability of ϵ. Informed traders will be willing to trade only when an event occurs and with the probability of μ, so that if they receive good news (sign), they will buy and if they receive bad news (sign), they will sell their shares; Therefore, assuming a bad information event occurs with a probability of $(\delta\alpha)$ on a given day, the entry rate of buy orders (α) will be lower than the entry rate of sell orders $(\mu + \epsilon)$ because for the informed traders with the occurrence of a good information event on a specific day with the probability of $(\alpha(1-\delta))$, the entry rate of buy orders $(\mu + \epsilon)$ will be higher than the entry rate of sell orders (ϵ). Under these circumstances, a market maker uses information to enter into trade based on the Bayesian inference to meet its expectations with good news, bad news or no news. The market maker's analysis for one day is independent of other days. With these interpretations, all four parameters $(\theta = \alpha, \mu, \delta, \epsilon)$ used in the PIN calculation formula are estimated by maximizing the following daily probability function:

$$P(B, S|no\ news) = \frac{e^{-\varepsilon} \times \varepsilon^{B}}{B!} \times \frac{e^{-\varepsilon} \times \varepsilon^{S}}{S!} \tag{3.6}$$

$$P(B, S|bad\ news) = \frac{e^{-\varepsilon} \times \varepsilon^{B}}{B!} \times \frac{e^{-\varepsilon+\mu} \times (\varepsilon+\mu)^{S}}{S!} \tag{3.7}$$

$$P(B, S|good\ news) = \frac{e^{-\varepsilon+\mu} \times (\varepsilon+\mu)^{B}}{B!} \times \frac{e^{-\varepsilon} \times \varepsilon^{S}}{S!} \tag{3.8}$$

Therefore, the probability function of trade on a day is equal to:

$$L(B,S|\theta) = (1-\alpha)P(B,S|no\ news) + \alpha\delta P(B,S|bad\ news) + \alpha(1-\delta)P(B,S|good\ news) \quad (3.9)$$

$$\begin{aligned} L\big((B,S)|\theta\big) = (1-\alpha)\times\frac{e^{-\varepsilon}\times\varepsilon^{B}}{B!}\times\frac{e^{-\varepsilon}\times\varepsilon^{S}}{S!} + \alpha\delta\times\frac{e^{-\varepsilon}\times\varepsilon^{B}}{B!}\times\frac{e^{-\varepsilon+\mu}\times(\varepsilon+\mu)^{S}}{S!} \\ + \alpha(1-\delta)\times\frac{e^{-\varepsilon+\mu}\times(\varepsilon+\mu)^{B}}{B!}\times\frac{e^{-\varepsilon}\times\varepsilon^{S}}{S!} \end{aligned} \quad (3.10)$$

The probability of buy order is equal to:

$$\begin{aligned} P(B) &= \sum_{S=0}^{\infty} P(B,S) \quad (3.11)\\ &= \sum_{S=0}^{\infty}\left[\alpha(1-\delta)e^{-(\mu+\varepsilon_b)}\frac{(\mu+\varepsilon_b)^{B}}{B!}e^{-\varepsilon_s}\frac{\varepsilon_s^{S}}{S!} + \alpha\delta e^{-\varepsilon_b}\frac{\varepsilon_b^{B}}{B!}e^{-(\mu+\varepsilon_s)}\frac{(\mu+\varepsilon_s)^{S}}{S!} + (1-\alpha)e^{-\varepsilon_b}\frac{\varepsilon_b^{B}}{B!}e^{-\varepsilon_s}\frac{\varepsilon_s^{S}}{S!}\right]\\ &= \alpha(1-\delta)e^{-(\mu+\varepsilon_b)}\frac{(\mu+\varepsilon_b)^{B}}{B!}e^{-\varepsilon_s}\sum_{S=0}^{\infty}\frac{\varepsilon_s^{S}}{S!} + \alpha\delta e^{-\varepsilon_b}\frac{\varepsilon_b^{B}}{B!}e^{-(\mu+\varepsilon_s)}\sum_{S=0}^{\infty}\frac{(\mu+\varepsilon_s)^{S}}{S!}\\ &\quad + (1-\alpha)e^{-\varepsilon_b}\frac{\varepsilon_b^{B}}{B!}e^{-\varepsilon_s}\sum_{S=0}^{\infty}\frac{\varepsilon_s^{S}}{S!}\\ &= \alpha(1-\delta)e^{-(\mu+\varepsilon_b)}\frac{(\mu+\varepsilon_b)^{B}}{B!} + \alpha\delta e^{-\varepsilon_b}\frac{\varepsilon_b^{B}}{B!} + (1-\alpha)e^{-\varepsilon_b}\frac{\varepsilon_b^{B}}{B!} \end{aligned}$$

$$\begin{aligned} E(B) &= \sum_{S=0}^{\infty} P(B)\times B\\ &= \sum_{B=0}^{\infty}\left[\alpha(1-\delta)e^{-(\mu+\varepsilon_b)}\frac{(\mu+\varepsilon_b)^{B}}{B!} + \alpha\delta e^{-\varepsilon_b}\frac{\varepsilon_b^{B}}{B!} + (1-\alpha)e^{-\varepsilon_b}\frac{\varepsilon_b^{B}}{B!}\right]\times B\\ &= \sum_{B=1}^{\infty}\left[\alpha(1-\delta)e^{-(\mu+\varepsilon_b)}\frac{(\mu+\varepsilon_b)^{B}}{(B-1)!} + \alpha\delta e^{-\varepsilon_b}\frac{\varepsilon_b^{B}}{(B-1)!} + (1-\alpha)e^{-\varepsilon_b}\frac{\varepsilon_b^{B}}{(B-1)!}\right]\\ &= \alpha(1-\delta)e^{-(\mu+\varepsilon_b)}(\mu+\varepsilon_b)\sum_{B=1}^{\infty}\frac{(\mu+\varepsilon_b)^{B-1}}{(B-1)!} + \alpha\delta e^{-\varepsilon_b}\varepsilon_b\sum_{B=1}^{\infty}\frac{\varepsilon_b^{B-1}}{(B-1)!}\\ &\quad + (1-\alpha)e^{-\varepsilon_b}\varepsilon_b\sum_{B=1}^{\infty}\frac{\varepsilon_b^{B-1}}{(B-1)!}\\ &= \alpha(1-\delta)(\mu+\varepsilon_b) + \alpha\delta\varepsilon_b + (1-\alpha)\varepsilon_b\\ &= \alpha(1-\delta)\mu + \varepsilon_b \end{aligned}$$

The probability of sell order is equal to:

$$
\begin{aligned}
P(S) &= \sum_{B=0}^{\infty} P(B,S) \qquad (3.12)\\
&= \sum_{B=0}^{\infty} \left[\alpha(1-\delta) e^{-(\mu+\varepsilon_b)} \frac{(\mu+\varepsilon_b)^B}{B!} e^{-\varepsilon_s} \frac{\varepsilon_s^S}{S!} + \alpha\delta e^{-\varepsilon_b} \frac{\varepsilon_b^B}{B!} e^{-(\mu+\varepsilon_s)} \frac{(\mu+\varepsilon_s)^S}{S!} + (1-\alpha) e^{-\varepsilon_b} \frac{\varepsilon_b^B}{B!} e^{-\varepsilon_s} \frac{\varepsilon_s^S}{S!} \right] \\
&= \alpha(1-\delta) e^{-(\mu+\varepsilon_b)} e^{-\varepsilon_s} \frac{\varepsilon_s^S}{S!} \sum_{B=0}^{\infty} \frac{(\mu+\varepsilon_b)^B}{B!} + \alpha\delta e^{-\varepsilon_b} \frac{(\mu+\varepsilon_s)^S}{S!} e^{-(\mu+\varepsilon_s)} \sum_{B=0}^{\infty} \frac{\varepsilon_b^B}{B!} \\
&\quad + (1-\alpha) e^{\varepsilon_s} \frac{\varepsilon_s^S}{S!} e^{-\varepsilon_b} \sum_{B=0}^{\infty} \frac{\varepsilon_b^B}{B!} \\
&= \alpha(1-\delta) e^{-\varepsilon_s} \frac{\varepsilon_s^S}{S!} + \alpha\delta e^{-(\mu+\varepsilon_s)} \frac{(\mu+\varepsilon_s)^S}{S!} + (1-\alpha) e^{-\varepsilon_s} \frac{\varepsilon_s^S}{S!}
\end{aligned}
$$

$$
\begin{aligned}
E(S) &= \sum_{S=0}^{\infty} P(S) \times S \\
&= \sum_{S=0}^{\infty} \left[\alpha(1-\delta) e^{-\varepsilon_s} \frac{\varepsilon_s^S}{S!} + \alpha\delta e^{-(\mu+\varepsilon_s)} \frac{(\mu+\varepsilon_s)^S}{S!} + (1-\alpha) e^{-\varepsilon_s} \frac{\varepsilon_s^S}{S!} \right] \times S \\
&= \sum_{S=0}^{\infty} \left[\alpha(1-\delta) e^{-\varepsilon_s} \frac{\varepsilon_s^S}{(S-1)!} + \alpha\delta e^{-(\mu+\varepsilon_s)} \frac{(\mu+\varepsilon_s)^S}{(S-1)!} + (1-\alpha) e^{-\varepsilon_s} \frac{\varepsilon_s^S}{(S-1)!} \right] \\
&= \alpha(1-\delta) e^{-\varepsilon_s \sum_{S=1}^{\infty}} \frac{\varepsilon_s^{S-1}}{(S-1)!} + \alpha\delta e^{-(\mu+\varepsilon_s)} \sum_{S=1}^{\infty} \frac{(\mu+\varepsilon_s)^{S-1}}{(S-1)!} + (1-\alpha) e^{-\varepsilon_s} \varepsilon_s \sum_{S=1}^{\infty} \frac{\varepsilon_s^{S-1}}{(S-1)!} \\
&= \alpha(1-\delta)\varepsilon_s + \alpha\delta(\mu+\varepsilon_s) + (1-\alpha)\varepsilon_s \\
&= \alpha\delta\mu + \varepsilon_s
\end{aligned}
$$

Therefore, the probability of informed trading is:

$$PIN = \frac{\alpha(1-\delta)\mu + \alpha\delta\mu}{\alpha(1-\delta)\mu + \varepsilon_b + \alpha\delta\mu + \varepsilon_s} = \frac{\alpha\mu}{\alpha\mu + 2\varepsilon} \qquad (3.13)$$

The probability of having a strong signal on the day of the news is:

$$e^{-(\mu+\varepsilon_b)} \frac{(\mu+\varepsilon_b)^{B_i}}{B_i!} e^{-\varepsilon_s} \frac{\varepsilon_s^{S_i}}{S_i!} \qquad (3.14)$$

The probability of having a weak signal on the day of the news is:

$$e^{-\varepsilon_b} \frac{\varepsilon_b^{B_i}}{B_i!} e^{-(\mu+\varepsilon_s)} \frac{(\mu+\varepsilon_s)^{S_i}}{S_i!} \qquad (3.15)$$

The probability of no important news on the trading day is:

$$e^{-\varepsilon_b} \frac{\varepsilon_b^{B_i}}{B_i!} e^{-\varepsilon_s} \frac{\varepsilon_s^{S_i}}{S_i!} \qquad (3.16)$$

In total, the probability of observing the number of trade on a trading day is equal to the weighted average of the three types of information:

$$L\big(\theta|(B_i,S_i)\big)=\alpha(1-\delta)e^{-(\mu+\varepsilon_b)}\frac{(\mu+\varepsilon_b)^{B_i}}{B_i!}e^{-\varepsilon_s}\frac{\varepsilon_s^{S_i}}{S_i!}+\alpha\delta e^{-\varepsilon_b}\frac{\varepsilon_b^{B_i}}{B_i!}e^{-(\mu+\varepsilon_s)}\frac{(\mu+\varepsilon_s)^{S_i}}{S_i!}+(1-\alpha)e^{-\varepsilon_b}\frac{\varepsilon_b^{B_i}}{B_i}e^{-\varepsilon_s}\frac{\varepsilon_s^{S_i}}{S_i!} \tag{3.17}$$

where the Lee and Ready's (1991) algorithm is commonly used to determine the trade direction. Also, in order to estimate the vector of parameter θ for a set of data related to buy and sell, i.e. $[M=(B_t,S_t)]$ on T trading days, the probability function of the product of daily probabilities can be used as follows:

$$L(\theta|M)\prod_{t=1}^{T}L(\theta|B_t,S_t) \tag{3.18}$$

Using numerical methods, this probability function is obtained for optimal values, which is in fact the estimation of the parameters related to the probability of informed trading. As noted, according to Easley et al [11], higher values of PIN in the range of 0 and 1 indicate higher private information or higher levels of information asymmetry,

Independent variable - Family Ownership (FO): In this study, the family ownership of corporates is considered as a moderator variable, and if corporate is a family one, the virtual variable is 1 and otherwise it is 0. According to research conducted in Iran, family corporates used in this study are corporates in which at least 20% of the shares is owned by family members, individually or in groups, or if the percentage of family ownership is less than 20%, they have at least one board member on behalf of the family in the corporate [19].

Controls variable: The following control variables are used to control the effect of some variables on the relationship between independent and dependent variables.

Corporate Size (CS): The corporate size measure is at the end of the year and is calculated based on the natural logarithm of the market value of the company's equity.

Corporate Growth Opportunity (M/B): The measurement of a company's growth opportunity is obtained by dividing the market value of the end of period by the book value of equity.

Debt Ratio (DR): The ratio of book value of the total debt to book value of the total assets.

Return on Equity (ROE): A measure of a company's profitability and is calculated by dividing net income after minus tax by the book value of the total equity.

Company Loss (CL): If the company's before-profit and -tax income is negative, the virtual variable is 1 and otherwise it is zero.

Operating Cash Flow Volatility (OCFV): The standard deviation of the company's operating cash flows over the past five years.

Stock Return Volatility (SRV): The standard deviation of a company's stock returns over the past 60 months.

3.3. Statistical models of research

In order to investigate the relationship between independent and dependent variables of the research, the multivariate regression model with the Panel data method is used. The model used in the multivariate regression method to test the hypotheses is as follows.

$$COC_{it}=\beta_0+\beta_1 PIN_{it}+\beta_2 FC_{it}+\beta_3 PIN_{it}\times FC_{it}+\sum_{j=1}^{7}\beta_j controls_{it}+\varepsilon_{it} \tag{3.19}$$

4. Research findings

4.1. Descriptive analysis

Some of the concepts of descriptive statistics of variables are represented in Table 1. The results show that in the studied companies, the average cost of equity is 0.22, meaning that on average 22% of the companies' financial resources are supplied through proprietary securities. The average cost of debt is 0.05, indicating that on average, 5% of companies' financial resources are provided through debt securities. In addition, the weighted average cost of capital is 0.15. According to Table 1, the results show that 21.24% of the studied companies are family-owned and 8.14% of the studied companies have reported loss.

Table 1: Descriptive statistics of research variables

Variable	Mean	Median	Max	Min	STD	J-b stat	Prob
COE	0.233	0.217	0.532	−0.083	0.158	6.326	0.042
COD	0.055	0.050	0.124	0.002	0.035	29.652	0.000
WACC	0.151	0.126	0.350	0.030	0.088	57.391	0.000
PIN	0.1	0.08	0.25	0.02	0.07	76.48	0.00
OCFV	0.086	0.079	0.181	0.027	0.041	51.345	0.000
SRV	0.980	0.851	20295	0.234	0.567	61.094	0.000
CS	6.094	6.037	7.356	5.055	0.574	13.294	0.001
CG	2.650	2.345	6.675	0.011	1.660	60.462	0.000
DR	0.618	0.628	0.974	0.270	0.188	12.172	0.002
ROE	0.297	0.285	0.845	−0.293	0.297	8.859	0.012

Variable	Class type	Frequency	Percentage
FC	Family-owned	120	21.24
	Not family-owned	445	78.76
CL	Unprofitable companies	46	8.14
	Profitable companies	519	91.86

Source: Research findings

5. Correlation analysis

The correlation test examines the initial relationship between variables (single-variable analysis). The results of Table 2 show that the correlation between the variable cost of equity and variables including corporate size (0.22), corporate growth (0.25), and return on equity (0.26) is positive and significant at the level of 1% and, with the variable debt ratio (-0.20) is negative and significant. This indicates that in larger companies, higher-growth companies, and companies with higher return on equity, the cost of equity is higher, and in companies with higher debt ratio, cost of equity is lower. Negative and significant correlation between the cost of equity and family ownership (-0.1) at the level of 5% and corporate loss (-0.08) at the level of 10% shows that in companies where family owners own higher percentage of ownership and in unprofitable companies, the cost of equity is lower. The correlation between the variable cost of debt and variables including cash flow volatility (0.15), and debt ratio (0.4) is positive and significant at the level of 1%. This indicates that in companies with high cash flow volatility and in companies with high debt ratio, the cost of debt is also high. However, the negative and significant correlation between the cost of debt and the rate of return on equity (-0.14) shows that in companies with high rate of return on equity, the cost of debt is lower.

Table 2: Pearson Correlation coefficient between research variables variables

Variable	COE	COD	WACC	PIN	FC	OCFV	SRV	CS	CG	DR	ROE	CL
COE	1											
COD	−0.04	1										
WACC	0.72***	0.03	1									
PIN	0.01	−0.01	0.05	1								
FC	−0.1**	0.02	−0.06	0.1**	1							
OCFV	0.04	0.15***	0.03	−0.01	0.05	1						
SRV	0.03	−0.03	0.00	0.08*	0.12***	0.04	1					
CS	0.22***	−0.03	0.24***	0.01	−0.17***	0.05	−0.01	1				
CG	0.25***	0.01	0.28***	0.09**	0.06	0.19***	0.19***	0.31***	1			
DR	−0.2***	0.4***	−0.39***	−0.00	−0.07*	0.08*	−0.02	−0.24***	0.04	1		
ROE	0.26***	−0.14***	0.42***	0.06	0.08*	−0.03	−0.02	0.33***	0.28***	−0.27***	1	
CL	−0.8*	0.03	−0.19***	0.00	−0.03	0.01	0.02	−0.16***	−0.16***	0.33***	−0.37***	1

Source: Research findings - (*, **, *** indicate the significance level of 10%, 5%, 1%).

6. Unit Root test of research variables

A variable is stable when its mean, variance, and covariance remain constant over time. In general, if the time origin of a variable changes and the mean, variance, and covariance doesn't change, then the variable is stable, otherwise the variable will not be stable. The results of the stability test are listed in Table 3. According to the tests, because the probability of all variables is less than 5%, all independent, dependent, and control variables during the research period were stable. As seen in Table 3, all variables are stable and there is no need for a co-integration test. Therefore, there will be no problem of spurious regression in estimation coefficients. In the spurious regression, the significance of the coefficients is spurious.

Table 3: Unit Root test of research variables

Variable	PP	ADF	I-P-S	L-L-C
COE	751.44***	641.63***	−50.45***	−201.83***
COD	325.46***	281.91***	−60.18***	−507.83***
WACC	455.37***	407.58***	−17.39***	−68.74***
PIN	499.19***	444.67***	−13.53***	−28.46***
OCFV	329.72***	274.49***	−5.49***	−25.15***
SRV	1337.6***	1276.28***	−150.29***	−250.57***
CS	818.30***	668.90***	−28.96***	−62.28***
CG	664.36***	572.18***	−29.56***	−94.31***
DR	294.34***	253.45*	−3.73***	−18.74***
ROE	291.08***	252.53*	−4.10***	−19.65***
FC	3.88	3.99	0.09*	−1.22***
CL	12.99	13.96	0.37	−1.74**

Source: Research findings - (*, **, *** is significant at 10%, 5%, 1%).

7. Tests of Multicollinearity between research explanatory variables

The most comprehensive criterion for investigating collinearity is the variance inflation factor. This measure shows how inflated the variance of the model coefficients is in the presence of collinearity

in compared to the absence of collinearity. When the variance inflation index is less than 10, it indicates lack of collinearity. According to Table 4, the results of this test reveal that the inflation rate of variance of independent and control variables in the research models is within its allowable limit and therefore there is no problem in this regard.

8. Multivariate analysis

In order to test the hypothesis, the results of estimating the model presented in Table 4 with the combined data approach are used. The 5% significance level of the Chow statistic shows that in estimating models, the fixed effect pattern takes precedence over the integrated data pattern. Also, the significance of Hausman statistic at the level of 5% shows that to estimate the models, the fixed effect pattern is superior to the random effect pattern. Therefore, the models are estimated using the fixed effect pattern and the results are presented in Table 4.

Table 4: Results of estimating the research model

	COE		COD		WACC		WACC		
	Model (1)		Model (2)		Model (3)		Model (4)		
	Coeff	t stat	Coeff	t stat	Coeff	t stat	Coeff	t stat	VIF
Constant	−0.05	−0.5	0.05	2.02**	0.19	3.62***	0.19	3.31***	—
PIN	0.08	4.29***	0.1	1.15	0.1	6.22***	0.06	2.45**	1.13
FC	—	—	—	—	—	—	−0.01	−1.8*	1.18
FCPIN	—	—	—	—	—	—	0.1	3.03***	—
OCFV	0.04	0.7	0.02	1.19	0.03	1.03	0.03	0.75	1.06
SRV	−0.00	−0.34	−0.00	−3.58***	0.01	3.42***	0.01	3.12***	1.15
CS	0.02	2.66***	−0.00	−0.33	−0.00	−0.73	−0.00	−0.78	1.52
CG	0.00	0.92	0.00	1.7*	0.01	4.78***	0.01	4.93***	1.39
DR	0.06	1.23	0.02	2.83***	−0.07	−4.76***	−0.07	−4.39***	1.31
ROE	0.00	0.17	−0.01	−3.25***	0.01	2.94***	0.01	3.49***	1.42
CL	−0.00	−0.35	0.00	1.88*	0.00	0.48	0.00	0.33	1.30
Adj. R square	0.96		0.96		0.98		0.98		
D-W statistic	1.99		1.72		2.36		2.37		
Chow statistic	6.03***		13.87***		17.24***		16.91***		
F- statistic	90.89***		91.44***		232.02***		153.5***		
Hausman statistic	30.76***		28.2***		33.22***		37.49***		

Source: Research findings - (*, **, ***indicate the significance level of 10%, 5%, 1%).

H1. There is a negative and significant relationship between the probability of informed trading and the company's cost of equity.
The results show that the coefficient of probability of informed trading (0.0767) and the corporate size (0.0165) variables is significant at the 1% level. The positive and significant coefficient of the probability of informed trading (0.0767) indicates that the higher the information asymmetry, the higher the cost of financing through equity will be.

H2. There is a negative and significant relationship between the probability of informed trading and the company's cost of debt.
The results show that the coefficient of corporate growth (0.001) and the corporate loss (0.0038) variables is significant at the 10% level and the coefficient of stock return volatility (-0.0029), debt ratio (0.015) and return on equity (-0.0071) variables is significant at the 1% level.

H3. There is a negative and significant relationship between the probability of informed trading and the company's weighted average cost of capital.

The results show that the coefficient of probability of informed trading (0.0972), stock return volatility (0.0102), corporate growth (0.0051), debt ratio (-0.0701), and return on equity (0.0142) variables is significant at the 1% level. The positive and significant coefficient of the probability of informed trading variable (0.0972) indicates that as the information asymmetry increases, the cost of financing through the weighted average cost of capital increases.

H4. Family ownership moderates the relationship between the probability of informed trading and the company's weighted average of cost of capital.
The results show that the coefficient of family ownership (-0.0140) variable at the level of 10%, and the coefficient of the probability of informed trading (0.0546) variable at the level of 5%, and the coefficient of family corporate * probability of informed trading (0.0997), stock return volatility (0.0128), corporate growth (0.0056), and return on equity (0.0143) variables at the level of 1% are significant. The positive and significant coefficient of family corporate* the probability of informed trading (0.0997) variable indicates that as the information asymmetry increases, the cost of financing through the weighted average cost of capital increases, too.

9. Discussion and conclusion

In this study, considering family ownership as the moderator variable, the relationship between the probability of informed trading and the cost of capital of 113 companies listed on the Tehran Stock Exchange during the years 2012-2016 has been investigated. The research method is correlational and multivariate regression using combined data with fixed effect regression model approach has been applied. The results of the hypothesis test (research evidence) show that there is a positive and significant direct relationship between the probability of informed trading and the cost of equity and the weighted average cost of capital. The family ownership variable has a positive and significant direct effect on the probability of informed trading and the weighted average cost of capital. Theoretical foundations of the research show that there is a strong relationship between cost of capital and investors' expectations. Disclosure of company information will cause investors to incur less losses in their trades, resulting in demand for less compensation. This will adjust the expectations from company and reduce the company's cost of capital. The quality of disclosure increases stock liquidity by reducing the trading cost through influencing the amount of information asymmetry (probability of informed trading) in the distribution of information between corporate managers and investors, and finally, it decreases cost of capital by reducing information risk. In other words, the cost of capital will increase as information asymmetry increases (probability of informed trading). It seems that in the Iranian stock market, the criterion of the probability of informed trading has a result consistent with the theoretical foundations of the research. The results of this study are in agreement with the findings of the research by Easley et al. [11] Easley & O'Hara [10] and He et al. [15]. Their research showed that there is a positive and significant relationship between information asymmetry (probability of informed trading) and cost of capital. It should be noted that the difference in the sample size of the research, difference in the structure of the companies under study, the use of different indicators and criteria for measuring variables, difference in standards and rules for providing information and difference in economic and political conditions between the two countries are the reasons for the inconsistency of the results of the present study with the results of other researchers. Therefore, the generalization of theories supporting the results obtained to the Iranian environment (emerging markets) should be done with more consideration because the results obtained may be due to the factors specific to Iranian markets. Therefore, acculturalization among investors and other information users regarding their greater familiarity with and use of basic and specific information of companies is necessary in order to reduce the information asymmetry of stocks. It is recommended

to the financial managers of companies and capital market executives to reduce the cost of capital by adopting appropriate policies, increasing the quality of disclosure of financial information, reducing the information asymmetry between traders, decreasing the probability of trading using private information and increasing liquidity of company and market stocks, as this will increase information efficiency and, consequently, the efficiency of capital market allocation. Future researchers are also suggested to use other criteria for information asymmetry or other methods of calculating cost of capital.

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